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DEPARTMENT OF ECONOMICS

RESEARCH MEMORANDUM

LIQUIDITY CONSTRAINTS AND THE KEYNESIAN CORRIDOR

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Liquidity Constraints and the Keynesian Corridor

by

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Abstract

The paper analyses the role of credit constraints in a macroeconomic model with sluggish prices. Three regimes are distinguished. If there is excess demand for loans the regime of credit rationing applies. In a situation of overliquidity the Wicksellian overinvestment regime comes into force. Between these extremes the economy is in the Keynesian regime with price adjustment and investment depending on the rate of capacity utilization. The dynamics of the system is characterised by a corridor à la Leijonhufvud. Inside the corridor the system is stable and exhibits hysteresis. Outside the corridor the model is unstable as a result of overinvestment (Wicksellian cumulative process) or underinvestment (credit rationing regime).

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1. Introduction

The concept of a corridor has a certain intuitive appeal. Dynamic systems may behave well if disturbances are not too large, but their behaviour may be of a run-away character when exposed to large shocks. As observed by Howitt (1978) the notion has a place in the history of economic thought. It can be at least implicitely associated with the literature on financial factors and economic stability as appears from the work of Fisher (1933) and Minsky (1986). The idea was strongly propagated by Leijonhufvud (1981) in his evaluation of Keynesian economics. In his view, inside the corridor multiplier effects are dominated by neoclassical market adjustments, so that the homeostatic mechanisms work well. If the system is displaced sufficiently far out, multiplier coefficients increase and there will be no return to a full employment equilibrium.

The theoretical construction of Leijonhufvud is intriguing but lacks clarity and precision both in economic and mathematical sense. From a mathematical point of view corridor effects relate to a system that is locally stable but globally unstable. Necessary conditions for this to be the case are discussed in Howitt (1978). In general terms, there need to be two forces: the deviation-counteracting and the deviation-amplifying feedback effects. And there has to be some non-linearity, so that for a small displacement of the equilibrium the system is stable, whereas for large shocks the deviation-amplifying force dominates. From an economic point of view Leijonhufvud's argument based on stabilizing price-effects versus destabilizing multiplier-effects calls for a specific concept of stability to make sense. Asymptotic stability, the familiar concept, is not appropriate for short-run Keynesian macroeconomics. Therefore, Howitt (1978) opts for direct stability, which holds if the motion is never again as bad as its initial position. Corridor effects then imply a temporary movement in the wrong direction as multiplier-effects dominate price-effects. The corridor effects are relative, because what really matters is how the system handles small perturbations compared with the performance following large displacements.

In this paper the corridor will be given a more solid foundation by returning to the concept of asymptotic stability.[1)] Our model is Keynesian in the sense that prices and wages do not move quickly to clear markets.[2)] More specifically, we assume that real wages are fixed and prices adjust to eliminate excess capacity in the commodity market. But this is not the end of the story, because excess capacity may also be cured by restricting capacity. Investment may be related to capacity utilization in a similar manner as changes in the price level. If both mechanisms operate simultaneously the economy exhibits hysteresis as discussed in Van de Klundert and Van Schaik (1990). The rationale behind this story is uncertainty with respect to future demand. If a firm believes that demand will stay at a too low level despite price concessions it may cut investment or close plants (e.g. Dixit, 1989, Bean, 1989). Although models exhibiting hysteresis will have one or more zero roots (in the case of differential equations) they may be stable in the sense that they will approach a well defined steady state which depends upon the initial conditions of the predetermined variables (e.g. Giavazzi and Wyplosz, 1985).

Corridor effects come into play if account is taken of the role of credit (bank loans) in financing fixed investment. If banks have low reserves credit may be rationed for reasons explained in Stiglitz and Weiss (1981 and 1987). Following Blinder (1987) we assume that credit rationing may curtail investment in fixed capital. Under these circumstances the price effect may be deviation-counteracting as well as deviation-amplifying, because rising prices in case of excess demand not only feed back on demand in a stabilizing manner but also diminish liquidity, which depresses investment and thus capacity expansion still further. Credit rationing introduces the non-linearity required for corridor effects to obtain. The regime of credit rationing may have its non-linear counterpart at the other end of the spectrum in the form of easy credit when liquidity positions are comfortable. Easy credit stimulates investment in fixed capital by way of a Wicksellian process without explicit reference to interest rates. The significance of the Wicksellian cumulative process is stressed by a number of authors (see for instance Haberler, 1966 and Leijonhufvud, 1981, Ch. 7). Here again the price effect is deviation-counteracting (through its effect on aggregate demand) and deviation-amplifying (through its effect on liquidity). Both non-linearities can be combined to a general non-linear relation between investment demand and credit supply. However, to obtain neat analytical results we will stick to a piecewise linear approximation of this non-linear function. As a result, we can distinguish three macroeconomic regimes.[3] At the one extreme is the regime of credit-rationing, while at the other extreme the Wicksellian overinvestment regime holds. In between credit plays no specific role and the corresponding regime is called Keynesian.

The paper is organized as follows. In section 2 the model is introduced and the different regimes with regard to commercial bank policies are marked out. Section 3 discusses the dynamic properties of the regimes and fits the pieces together to obtain a two-sided corridor result.[4)] To get analytical results it proves to be necessary to linearize the model around a steady state solution. Comparative static results conclude section 3. These results are illustrated in section 4 by way of numerical examples. The paper closes with some conclusions.

2. Credit supply and investment

As stressed in the modern theory on imperfect information credit rationing may be important. Because moral hazard and adverse selection problems are encountered banks may allocate credit without manipulating the lending rate (e.g. Stiglitz and Weiss, 1981). Credit rationing may have significant macroeconomic consequences as analysed in Blinder (1987). Here we want to pursue this idea by introducing different credit regimes in a macroeconomic model with Keynesian features. Credit may be necessary to finance working capital or investment in fixed capital. In the latter case conditions on the credit market will have an influence on aggregate demand through investment and on aggregate supply over time through capital accumulation. In this paper working capital and inventories will be ignored to focus on the macroeconomic consequences of financing investment in fixed capital by bank loans.

The supply of credit by banks depends on bank reserves which can be controlled by the Central Bank. Moreover, it could be assumed that the supply of credit is positively related to national income for two reasons. First, if income increases banks will hold less excess reserves because the probability of default declines so that loans become less risky. Second, banks may shift their portfolio shares toward higher yield loans if income rises. Following Blinder (1987) the supply of credit (C^s) may be written in compact form as:

$$\frac{C^s}{P} = \frac{L}{P} + \alpha Y \qquad (2.1)$$

where Y, P and L denote real output, the aggregate price level and a measure of bank reserves respectively. In the analysis of Blinder credit is rationed if the demand for credit exceeds the supply of credit. In such a situation investment plans (notional investment demand) must be revised to meet the credit constraint. If this constraint is not binding investment in fixed capital is independent of the conditions in the credit market. In a more general setting one could define excess supply of credit as the difference between the volume of loans available and the demand for credit:

$$Z \equiv \frac{C^s}{P} - \frac{C^d}{P}$$

The variable Z could then be used to explain effective real investment (I) along with other variables based on profit maximization by firms.

Insert Figure 1 here

A plausible non-linear relation between Z and I is shown in Figure 1. For low and probably negative values of Z investment is curtailed as the banks have to satisfy their reserve ratios, whereas at relatively high values of Z investment is stimulated as competition forces banks to soften the conditions for obtaining credit. In an intermediate range the relation between excess demand for credit and investment is weak or nearly absent. Here we shall approximate this non-linear relation by distinguishing three regimes (see the broken lines in Figure 1). For negative values of Z we assume that credit is rationed as in Blinder (1987). This regime may be called the credit-rationing or underinvestment regime (C-regime). For relative high (positive) values of Z ($>\bar{Z}$) we postulate a simple linear relationship between I en Z. As will be explained below we may call this the overinvestment regime. This regime has some features in common with the Wicksellian cumulative process and may therefore be labelled as the W-regime. Following Blinder the intermediate position will be earmarked as the Keynesian regime (K-regime), because its yields a familiar Keynesian solution.

A central feature of our model is that prices adjust slowly in case of excess demand in commodity markets. Therefore, output is demand-determined in the short run. Aggregate demand (Y) comes from a linear consumption function in income and real cash balances and from investment

$$Y = A + bY + s\frac{L}{P} + I \tag{2.2}$$

Autonomous expenditure is subsumed under A, whereas b is the marginal propensity to consume and s indicates the wealth effect of outside money on consumption.[5)]

Firms invest in fixed capital to bring capacity output in line with aggregate demand. It is assumed that the real wage and the real interest rate are constant, so that the cost-minimizing combination of labour and capital is fixed. Moreover, with constant returns to scale the capital-output ratio is constant, so that output capacity can be directly related to the stock of capital: $\bar{Y} = K/\kappa$. The investment equation in the Keynesian regime then becomes

$$I = \beta[(Y/\bar{Y})-1]K + \delta K \tag{2.3}$$

where the second term in the RHS relates to replacement investment. The rate of depreciation δ is constant. Substitution of (2.3) in (2.2) gives the conventional Keynesian output formula

$$Y = \frac{1}{1-b-\beta\kappa}\left[A + s\frac{L}{P} + (\delta-\beta)K\right] \tag{2.4}$$

The development of the system over time depends upon the state variables P and K. Capital is accumulated according to

$$\dot{K} = I - \delta K \tag{2.5}$$

where a dot over a variable indicates a time derivative. Relative changes in the price level depend upon the level of excess demand in the market for goods:

$$\dot{P} = \lambda[(Y/\bar{Y})-1]P \tag{2.6}$$

Disequilibrium in the market for goods may lead to unemployment or overemployment inducing changes in the nominal wage rate. The assumption of a constant real wage implies that nominal wages move at the same rate as prices. However, there is no need to suppose that excess demand in the labour market has a direct impact on price changes as postulated in Blinder (1987). A proper analysis of the labour market would focus on changes in the real wage rate, but that would take us too far in the present context.

Insert Figure 2 here

After the appropriate substitutions the dynamics of the model can be characterised by a pair of differential equations in the endogenous variables P and K

$$\dot{P} = \lambda m[\kappa A + s\kappa\frac{L}{P} - (1-b-\delta\kappa)K]\frac{P}{K} \tag{2.7}$$

$$\dot{K} = \beta m[\kappa A + s\kappa\frac{L}{P} - (1-b-\delta\kappa)K] \tag{2.8}$$

where $m=1/(1-b-\beta\kappa)$ is the Keynesian multiplier. A simple dynamic system like this exhibits hysteresis as discussed in Van de Klundert and Van Schaik (1990). As appears from equations (2.7) and (2.8) the $\dot{P}=0$ locus and the $\dot{K}=0$ locus coincide and can be expressed as

$$K = \frac{\kappa}{1-b-\delta\kappa}[A + s\frac{L}{P}] \tag{2.9}$$

The corresponding phase diagram is given in Figure 2. Starting from a point in the Keynesian regime the system may move toward a stable equilibrium (points A and B) or cross one of the borders of the Keynesian regime (points A' or B'). In the latter case the dynamics of the system are no longer determined by the pair of differential equations (2.7) and (2.8). What will happen in these cases will be analysed in the next section. But first we have to derive expressions for the borders separating the different regimes.

Ignoring working capital the demand for credit (C^d) equals end-of-period fixed capital

$$\frac{C^d}{P} = (1-\delta)K + I \tag{2.10}$$

Credit rationing is not on the agenda as long as

$$\frac{C^s}{P} \geq \frac{C^d}{P} \tag{2.11}$$

The border between the C-regime and the K-regime can therefore be obtained by assuming that credit demand in the Keynesian regime just equals the available supply of credit. Ignoring the inequality sign in (2.11) and substituting equations (2.1), (2.3), (2.4) and (2.10) we get

$$K = \frac{[(1-b-\beta\kappa) + s(\alpha-\beta\kappa)]\frac{L}{P} + (\alpha-\beta\kappa)A}{(\delta-\beta)(\beta\kappa-\alpha) + (1-\beta)(1-b-\beta\kappa)} \tag{2.12}$$

The W-regime will be relevant if the supply of credit is large in comparison with the demand for credit. Assuming this to be the case if a threshold $\bar{Z}$ is passed the overinvestment regime applies for

$$\frac{C^s}{P} \geq \frac{C^d}{P} + \bar{Z} \tag{2.13}$$

It should be clear from this definition that the border between the K-regime and the W-regime runs parallel with the border between the K-regime and the C-regime. In Figure 2 both borders are drawn under the assumption that the slope of the $\dot{K}=\dot{P}=0$ locus exceeds that of the borders. The border between the K-regime and the C-regime is the line BB, whereas the border between the K-regime and the W-regime is the line B'B'. The W-regime is characterised by excessive investment behaviour as banks push firms to undertake more risky projects. Changes in the supply side of money may depress the money interest rate below its equilibrium level and thus start a Wicksellian cumulative process which necessarily ends in crisis and depression (e.g. Haberler, 1966). To keep in line with the rest of the paper we assume that there is a direct transmission mechanism between excessive supply of credit in real terms $(Z-\bar{Z}>0)$ and real investment. The investment equation for the W-regime will therefore be written as

$$I = \beta\left[\frac{Y}{\bar{Y}} - 1\right]K + \delta K + \varepsilon\left[\frac{C^S}{P} - \frac{C^d}{P} - \bar{Z}\right] \tag{2.14}$$

This completes the introduction of our model. The implications of capital accumulation and price adjustment under the credit rationing and the overinvestment regime will be discussed in section 3. In this section we shall give a complete picture of the dynamics of the model.

3. The stable Keynesian corridor

To derive analytical solutions it is necessary to linearize the model. In this section we will therefore apply a log-linear version of the model, which can be found by linearizing around a steady state solution. The logarithm of a variable is denoted by a small letter. Coefficients resulting from the process of linearization are evaluated at a steady state in the K-regime with $I=\delta K$, $C^S=C^d$ and $Y/\bar{Y}=1$.

There are a number of equations which hold irrespective of the regime which rules. Output is always demand-determined as shown in equation (2.2). The log-linear expression for this equation is

$$y = \omega a + by + s\mu(\ell - p) + \sigma i \tag{3.1}$$

where ω, μ and σ denote the share of autonomous expenditure in output, the liquidity ratio and the share of investment in output in the initial steady state respectively. It should be observed that the coefficients of (3.1) are positive and add up to one $(1=\omega+b+s\mu+\sigma)$ and that in long-run equilibrium $\sigma=\delta\kappa$. Price formation is given by equation (2.6), which becomes after linearization

$$\dot{p} = \lambda(y-k) \tag{3.2}$$

The accumulation function (2.5) can be written in log-linear form as

$$\dot{k} = \delta(i-k) \tag{3.3}$$

In the <u>K-regime</u> firms invest to adjust capacity to demand as shown in equation (2.3). Linearization of this equation results in

$$\sigma i = \beta\kappa y + (\sigma-\beta\kappa)k \tag{3.4}$$

The Keynesian investment function (3.4) and the accumulation equation (3.3) can be combined to

$$\dot{k} = \beta(y-k) \tag{3.5}$$

Substitution of (3.4) into (3.1) gives output in the Keynesian regime in terms of the state variables p and k

$$y = \frac{1}{1-b-\beta\kappa}\,[\omega a + s_\mu(\ell-p) + (\sigma-\beta\kappa)k] \tag{3.6}$$

The equations of motion in the K-regime are now

$$\dot{p} = \frac{\lambda}{1-b-\beta\kappa}\,[\omega a + s_\mu(\ell-p) - (1-b-\sigma)k] \tag{3.7}$$

$$\dot{k} = \frac{\beta}{1-b-\beta\kappa}\,[\omega a + s_\mu(\ell-p) - (1-b-\sigma)k] \tag{3.8}$$

As can be easily checked the dynamic system (3.7) and (3.8) has a zero root, reflecting hysteresis and a negative root, which stabilizes. Therefore starting from an initial position the system converges to the $\dot{k}=\dot{p}=0$ locus:

$$p = \ell + \frac{\omega}{s_\mu}a - \frac{1-b-\sigma}{s_\mu}k \tag{3.9}$$

As shown in Giavazzi and Wyplosz (1985) the steady state solution of k and p depends upon the initial conditions. As a consequence the long-run values of the state variables are determined by the history of the exogenous variables and the speeds of adjustment, β and λ in our model.

In the C-regime credit is rationed, so that investment is determined residually by equating demand for credit and supply of credit

$$\sigma i = \mu(\ell - p) + \alpha y + (\sigma - \kappa)k \tag{3.10}$$

Substitution of this result in (2.1) yields a solution for output in case of credit rationing

$$y = \frac{1}{1-b-\alpha}[\omega a + (1+s)\mu(\ell - p) + (\sigma - \kappa)k] \tag{3.11}$$

Comparing equations (3.6) and (3.11) it can be concluded that the multiplier with respect to autonomous expenditure is larger in the Keynesian regime if $\beta > \frac{\alpha}{\kappa}$. This inequality will hold for small values of the credit multiplier α. In the extreme case $\alpha=0$ rationing of investment in the C-regime leads definitely to a lower multiplier of autonomous spending. Without loss of generality we shall assume in the sequel of the paper that $\alpha=0$. The effect of a change in reserves (ℓ) on output is not easily comparable. A sufficient condition for the effect to be larger in the C-regime is that the multiplier in this regime is not smaller than the multiplier in the K-regime.

The equation of motion for the price level in the regime of credit rationing can be found by substituting (3.11) in (3.2)

$$\dot{p} = \frac{\lambda}{1-b}\{\omega a + \mu(1+s)(\ell - p) - [(\kappa - \sigma) + (1-b)]k\} \tag{3.12}$$

The equation of motion for the state variable k follows from equations (3.3), (3.10) and (3.11)

$$\dot{k} = \frac{1}{\kappa(1-b)}[\mu(1-b)(\ell - p) - \kappa(1-b)k] \tag{3.13}$$

A linear expression for the border between the K-regime and the C-regime can be obtained by the procedure sketched in section 2. Equating the demand for credit according to the Keynesian regime with the supply of credit results after some algebraic manipulations in

$$p = \ell + \frac{1}{\mu[1-b-\beta\kappa(1+s)]}\{-\beta\kappa\omega a - \kappa[(1-\beta)(1-b) - \beta(\kappa - \sigma)]k\} \tag{3.14}$$

Insert Figure 3 here

The border separates the regimes as shown in Figure 3, where equation (3.14) is indicated by the broken line BB. It should be noticed that the slope of the border may be positive or negative. For reasonable values of the parameters the slope will be negative as drawn in Figure 3. Below the BB-line the Keynesian regime exhibiting hysteresis prevails. Above the line the differential equations of the C-regime, (3.12) and (3.13), govern the movements of the state variables k and p. The slope of the $\dot{p}=0$ locus is larger than the slope of the $\dot{k}=0$ locus as can be proved (see appendix). The $\dot{p}=0$ and $\dot{k}=0$ locus intersect at the point $k = a$ and $p = \ell-a$. These coordinates satisfy the border equation (3.14) as can be easily checked. Following the arrows in the phase diagram it appears that the C-regime is unstable. Credit rationing if sustained will lead to stagflation, i.e. rising prices and declining production capacities. If the credit constraint is binding output capacity is curtailed, which leads to increasing utilization rates and rising prices. As prices increase the real supply of credit diminishes and the constraint on investment is reinforced.

In the <ins>W-regime</ins> investment depends upon the rate of capacity utilization and excess liquidity according to equation (2.14). The log-linear transformation of this equation yields

$$\sigma i = \hat{\beta}\kappa y + [\sigma-\kappa(\hat{\beta}+\hat{\varepsilon})]k - \hat{\varepsilon}\zeta + \hat{\varepsilon}\mu(\ell-p) \tag{3.15}$$

where ζ denotes the liquidity threshold as a percentage of aggregate demand ($\zeta \equiv d\bar{Z}/Y=\bar{Z}/Y$). To simplify somewhat the following short-hand notation is introduced: $\hat{\beta}\equiv\beta/(1+\varepsilon)$ and $\hat{\varepsilon}\equiv\varepsilon/(1+\varepsilon)$. It should be recalled that $\alpha=0$. This assumption fits naturally in the W-regime as credit is already abundant and there is no need to supply more in connection with a rise in output. Substitution of (3.15) in (3.1) results in the following expression for output in the overinvestment regime:

$$y = \frac{1}{1-b-\hat{\beta}\kappa}\{\omega a + \mu(\hat{\varepsilon}+s)(\ell-p) - \hat{\varepsilon}\zeta + [\sigma-\kappa(\hat{\beta}+\hat{\varepsilon})]k\} \tag{3.16}$$

As may be observed by comparing (3.16) and (3.6) the multiplier is now smaller than in the K-regime. An increase in autonomous expenditure diminishes excess liquidity, so that investment will be reduced. The multiplier must therefore be lower in this case. An increase in bank reserves (ℓ>0) has a greater impact in the W-regime compared with the K-regime, because investment is stimulated directly by a rise in (excess) liquidity.

The equations of motion for the W-regime can be derived in the same manner as in the other regimes. After some straightforward algebraic manipulations we get

$$\dot{p} = \frac{\lambda}{1-b-\hat{\beta\kappa}} \{\omega a + \mu(\hat{\varepsilon}+s)(\ell-p) - \hat{\varepsilon}\zeta - [(1-b-\sigma) + \hat{\varepsilon}\kappa]k\} \tag{3.17}$$

$$\dot{k} = \frac{1}{\kappa(1-b-\hat{\beta\kappa})} \{\hat{\beta}\kappa\omega a + \mu[(1-b)\hat{\varepsilon} + s\hat{\beta}\kappa](\ell-p) - (1-b)\hat{\varepsilon}\zeta - [(1-b-\sigma)\hat{\beta}\kappa + (1-b)\hat{\varepsilon}\kappa]k\} \tag{3.18}$$

The equations of motion (3.17) and (3.18) hold below the border between the K-regime and the W-regime. At this border excess liquidity in the Keynesian regime just equals $\bar{Z}$. In log-linear form this condition is given by

$$\mu(\ell-p) - \zeta = (\kappa-\sigma)k + \sigma i, \text{ where } \zeta>0 \tag{3.19}$$

Substitution of investment and output according to the Keynesian regime results in the expression

$$p = \ell + \frac{1}{\mu[1-b-\beta\kappa(1+s)]}\{-\beta\kappa\omega a -(1-b-\beta\kappa)\zeta -\kappa[(1-\beta)(1-b)-\beta(\kappa-\sigma)]k\} \tag{3.20}$$

As appears from equations (3.14) and (3.20) the border between different regimes runs parallel. In Figure 3 the border between the K-regime and the W-regime is indicated by the broken line B'B'. Figure 3 is completed by drawing the $\dot{k}$=0 and $\dot{p}$=0 locus for the overinvestment regime. The $\dot{p}$=0 and $\dot{k}$=0 locus intersect at the point $k = a + \zeta s/\omega$ and $p = \ell - a - \zeta(s\mu+\omega)/\mu\omega$. These coordinates satisfy the border equation (3.20) as can be easily verified. (In Figure 3 it is assumed that ℓ>a>0.) Moreover, it can be shown that the slope of the $\dot{p}$=0 locus exceeds that of the $\dot{k}$=0 locus (see appendix).

Following the arrows in the phase diagram it appears that the W-regime is unstable. To a certain extent the development on entering the W-regime mirrors that of a transition from the K-regime to the C-regime. In the latter case the result is a process of ongoing stagflation. In the W-regime there is a deflationary spiral, which can be explained as follows. If this regime comes into force investment is pushed, so that output capacity is positively affected. At the same time the multiplier decreases as shown above. This has a negative impact on demand. On balance the utilization rate declines, which leads to price concessions. The fall in the aggregate price level induces excess liquidity, which stimulates investment further. These developments are reinforced in the course of time and the model in unstable as a result of overinvestment.

Insert Figure 4 here

Fitting the different pieces together it can be concluded that there is a stable (Keynesian) corridor as shown in Figure 4. The stable region is bounded by the separatrix SS respectively S'S'. For initial values of the state variables inside the corridor the system moves towards a point on the $\dot{p}=\dot{k}=0$ locus of the K-regime, exhibiting hysteresis as explained above. If the initial values of k and p lie outside the corridor the system is unstable and policy measures are needed to rescue the economy. Possible developments are illustrated in Figure 4 by trajectories of k and p starting from different initial values.

It should be noticed that these trajectories may cross the borders of the different regimes. For instance, an increase in autonomous demand (a) shifts the $\dot{k}=0$ and $\dot{p}=0$ locus in all regimes in a South-East direction. Suppose that the initial situation is one of equilibrium in the Keynesian regime. The initial situation after the change in a is given by point A' in Figure 4. The rise in autonomous spending leads to an increase in capacity utilization, so that prices rise and investment is positive. These developments may be reinforced and the system may cross the border of the K-regime and the C-regime with prices and capital still increasing. However, on entering the C-regime the growth in the capital stock slows down and will come to a stop eventually. The result is a situation of stagflation with continuously increasing prices, a declining capital stock and rising utilization rates.

In case of a fall in autonomous spending the result may be just the opposite. In this case the initial situation could be point B' in Figure 4, which relates again to a Keynesian equilibrium before the demand shock hits the system. The price level falls under impact of a drop in aggregate demand and investment will be negative. Liquidity positions become abundant and the system may cross the border between the K-regime and the W-regime. Then the decline of the capital stock is checked and the movement may run out of hand. Prices fall further and further, but the capital stock increases. The rate of capacity utilization falls towards zero in this unstable situation.

Whether the system remains in the stable corridor or comes into the unstable regions depends upon the nature and extent of the shocks pertaining to the exogenous variables (autonomous spending and bank reserves). An increase in autonomous expenditure may lead to a trajectory starting in point A. The resulting development is stable, but the system will not return to the original equilibrium, because of the hysteresis property. Similar conclusions hold in case of a fall in autonomous spending where point B marks the initial position.

Changes in bank reserves (ℓ) can be analysed in an analogous manner. An increase (decrease) in bank reserves shifts the $\dot{p}=0$ locus and the $\dot{k}=0$ locus in all regimes to the North (South). This may also give rise to trajectories which cross borders between the regimes and unstable developments. Therefore, it can be concluded that there is a role for fiscal and monetary policy, that is preventing the economy to run out the stable corridor. If credit rationing becomes an issue bank reserves should be expanded and fiscal policy should be restrictive. In reverse, when credit is abundant monetary policy should be restrictive and fiscal policy should be stimulating to absorb the credit overhang.

In the next section we will illustrate the dynamic results by presenting numerical examples of the time paths of the endogenous variables.

4. Numerical examples

A starting point for constructing numerical examples is to consider the position of the lines of the phase diagram as drawn in Figure 3. From this it appears that the regimes are well distinguished from each other if both for the C-regime and the W-regime the slope of the the $\dot{k}=0$ locus exceeds the slope of the border. For reasonable values of the parameters this condition will hold as shown by the following example:[6)]

Borders: $p = \ell - 0.87k - 0.13a$ and $p = \ell - 0.87k - 0.13a - 1.04\zeta$

C-regime: $p = \ell - 1.23k + 0.23a$ $(\dot{p}=0)$ and

$p = \ell - 1.00k + 0.00a$ $(\dot{k}=0)$

K-regime: $p = \ell - 4.00k + 3.00a$ $(\dot{p}=\dot{k}=0)$

W-regime: $p = \ell - 2.56k + 1.56a - 0.48\zeta$ $(\dot{p}=0)$ and

$p = \ell - 1.75k + 0.75a - 0.75\zeta$ $(\dot{k}=0)$

Insert Figure 5 here

We consider the effects of (I) a combination of an expansionary fiscal and monetary policy ($a=3$, $\ell=6$), (II) an expansionary fiscal policy ($a=3$), (III) a moderate contractionary fiscal shock ($a=-1$) and (IV) a strong contractionary fiscal shock ($a=-3$). The time paths of prices and capital are shown in Figure 5.[7)] It should be noted that the initial position of the system is given by $a=\ell=0$, so that all initial values are zero.[8)]

The combination of an expansionary fiscal and monetary policy (I) leads to a position of the system as drawn in Figure 4. The initial values of k and p lie inside the corridor, so that the system is stable. On impact of the shock the system is in the W-regime, but it crosses the border with the K-regime at t=4. Both prices and capital rise and in the long run a point on the $\dot{p}=\dot{k}=0$ locus of the K-regime is attained. Leaving out monetary policy, an expansionary fiscal policy (II) places the initial values of p and k in the C-regime outside the corridor. The result is a situation of stagflation.

A contractionary fiscal policy may force the system into the W-regime. This will not happen in case of a moderate shock (III). The system starts within the K-regime and stays there. In case of a strong negative demand shock (IV) however the system also starts within the K-regime, but after some while it crosses the border with the W-regime. This is caused by growing liquidity, exceeding the liquidity threshold at a certain moment. The result is an unstable movement with a lasting fall in the rate of capacity utilization, notwithstanding rising output levels.

5. Conclusions

The introduction of liquidity constraints in a Keynesian model of price adjustment and capital accumulation results in a stable corridor. Inside this corridor the economy attains a steady state, but the result depends upon the initial conditions, which shows that there is some form of hysteresis. Outside the corridor the system is unstable in both directions. If credit is too tight, investment is curtailed so that capacity growth falls behind the growth in aggregate demand. The result is a process of stagflation, which goes on for ever. If credit is too loose, firms take somewhat more risk and invest more than they do otherwise. Banks stimulate (push) their clients to do so. The resulting overinvestment leads to ever declining utilization rates and an accelerating fall in prices.

Coordinated monetary policy and fiscal policy should keep the economy in the right track, that is inside the corridor. This does not mean that credit rationing or easy credit is always wrong. What it means is, that the economy should not be too far out in both directions, because otherwise instable forces take over and there will be no steady state at the horizon. Of course, the unstable trajectories should primarily be conceived as sign post for what might go wrong. If the economy sets course on an instable trajectory something in the model may break down and the system may settle down to some equilibrium. This brings us back to the observation in Howitt (1978), referred to in the introduction of our paper, that corridor-effects involve only relative measures. However, this time relatively is not caused by the variation in (short-run) stability concepts, but by the limitations of model building.

The idea of a Keynesian corridor remains a fascinating topic for research. Our analysis shows the viability of the concept, but has more of a beginning than of mature theory. It may be worthwile to check the robustness of the idea by extending the model in several directions. For instance, it might be useful to consider the labour market more explicitely than was done here. Moreover, alternative specifications of price adjustment and investment equations may be tested. More generally, this points to the specific micro foundations of Keynesian macroeconomics, which is almost terra incognita.

Footnotes

1. Our concept of corridor stability differs from the one based on a subcritical Hopf bifurcation (e.g. Gabisch and Lorenz, 1989, Ch. 4.) Instead of generating limit cycles, our theory builds on the distinction between credit regimes.

2. For a typology of Keynesian theory see for instance Blinder (1988).

3. Regime switching as a means of creating non-linearities is discussed in more general terms in Ferri and Greenberg (1989, Ch. 2).

4. Van Ewijk (1989, Ch. 5) finds a one-sided corridor effect in a non-linear model of price adjustment and capital accumulation, which differs from our model by introducing transaction cashes and interest rates.

5. It should be borne in mind that outside money is defined in the usual way as currency plus bank deposits matched by bank reserves.

6. The parameters values are: $\zeta=3$, $\kappa=1$, $\mu=1$, $b=1/2$, $\omega=1/4$, $s=1/12$, $\alpha=0$, $\beta=1/6$, $\varepsilon=1/12$, $\delta=1/6$, $\sigma=1/6$ and $\lambda=1/6$. As sensitivity analysis shows the system will preserve the required properties (i.e. the slope of the borders is larger than minus one) for small changes of these parameter values.

7. We thank Anton Markink and Dick Klapwijk for their help with the computations. The computer programme is available on request.

8. An alternative option, which is used in explaining Figure 4, is to define initial positions somewhere within of without the corridor. This implies non-zero initial values of p and k (and consequently of a and or ℓ).

Appendix

This appendix shows the conditions for the slope of the $\dot{p}=0$ locus to be larger in absolute value than the slope of the $\dot{k}=0$ locus in both the C-regime and the W-regime. As appears from equations (3.12) and (3.13) the slope of the $\dot{p}=0$ locus is larger than the slope of the $\dot{k}=0$ locus in the C-regime if

$$\frac{(\kappa-\sigma) + (1-b)}{\mu(1+s)} > \frac{\kappa}{\mu} \tag{A.1}$$

Notice that the coefficients resulting from the process of linearization are evaluated at a steady state with $I=\delta K$ and $C^s=C^d$, so that $\sigma=\delta\kappa$ and $\mu=\kappa$. (Notice also that $\alpha=0$.) In addition we have: $1=b+\omega+s\mu+\sigma$. Substituting these identities into (A.1) results in

$$\omega>0 \tag{A.2}$$

Condition (A.2) implies that in the steady state autonomous expenditure should be positive.

For the W-regime we can proceed in the same manner. From equations (3.17) and (3.18) we get that the slope of the $\dot{p}=0$ locus is larger in absolute value than the slope of the $\dot{k}=0$ locus if

$$\frac{(1-b-\sigma) + \hat{\varepsilon}\kappa}{\mu(s+\hat{\varepsilon})} > \frac{(1-b-\sigma)\hat{\beta}\kappa + (1-b)\hat{\varepsilon}\kappa}{\mu[(1-b)\hat{\varepsilon} + s\beta\kappa]} \tag{A.3}$$

Substitution of the appropriate identities gives

$$\frac{s\mu + \hat{\varepsilon}\mu + \omega}{s\mu + \hat{\varepsilon}\mu} > \frac{s\mu\hat{\beta} + (1-b)\hat{\varepsilon} + \omega\hat{\beta}}{s\mu\hat{\beta} + (1-b)\hat{\varepsilon}} \tag{A.4}$$

which comes down to

$$(1-b)>\hat{\beta}\kappa \qquad (A.5)$$

Condition (A.5) implies that the multiplier in equation (3.16) should be positive.

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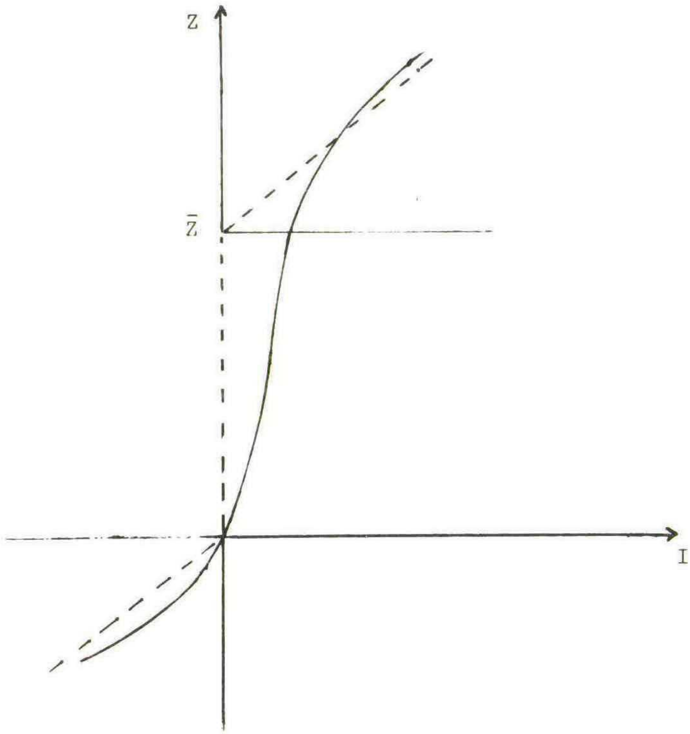

Figure 1

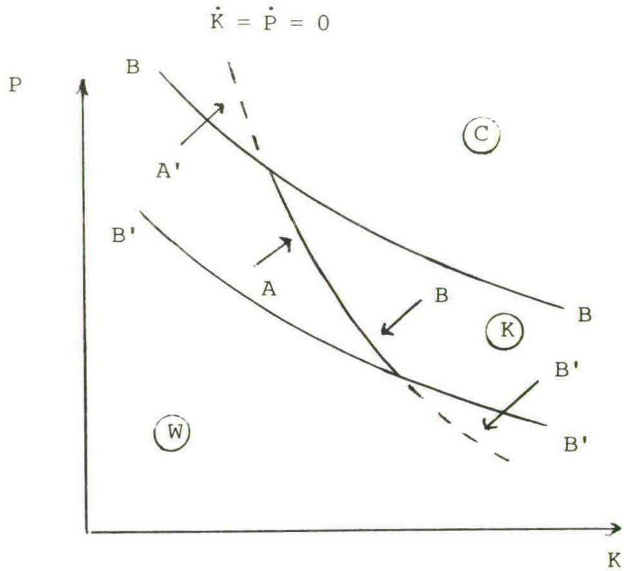

Figure 2

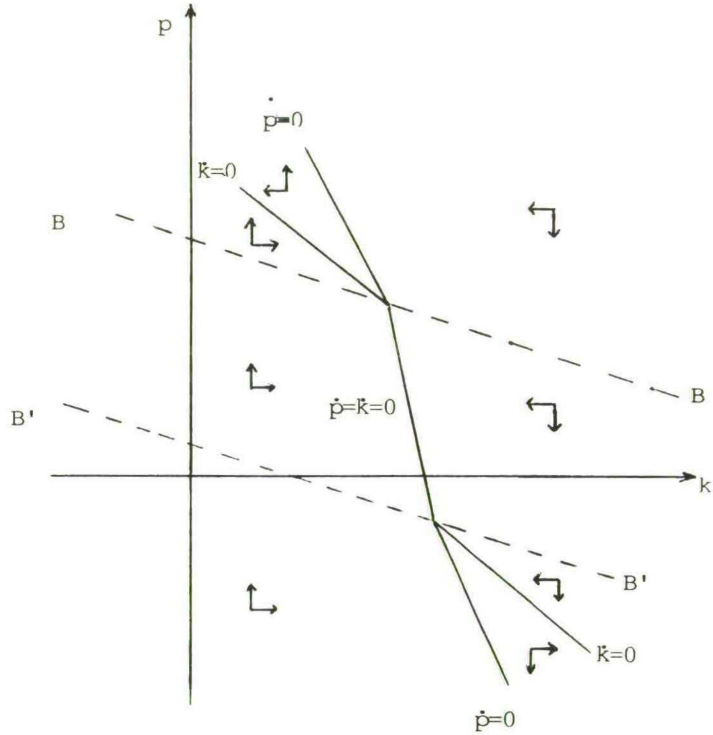

Figure 3

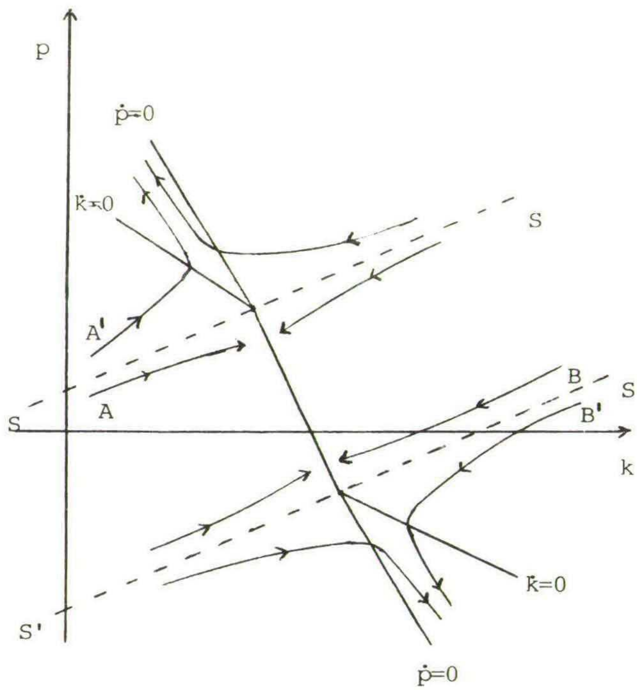

Figure 4

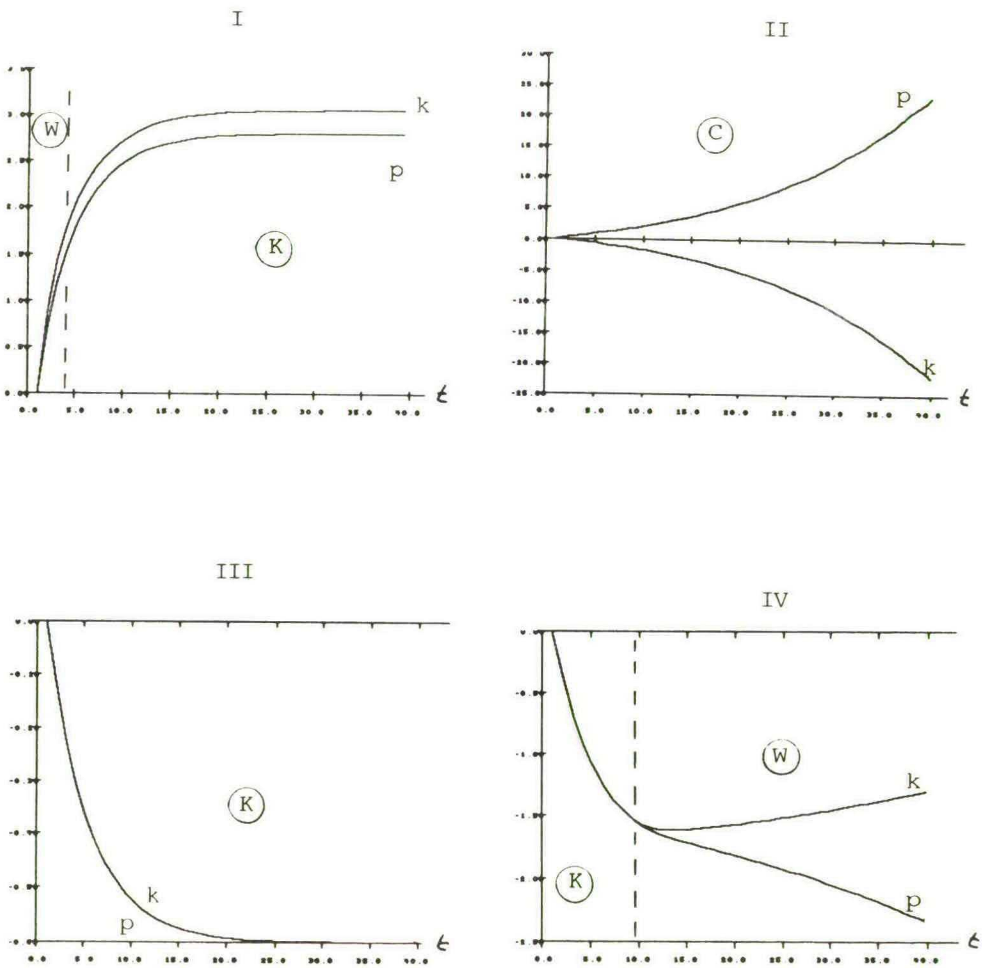

Figure 5

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